THE NIZI PROPERTY: A CLASSIC (EOCENE?) EPITHERMAL GOLD SYSTEM IN FAR NORTHERN BRITISH COLUMBIA

By Heather Plint, Shear Quality Consulting Ltd., William J. McMillan and JoAnne Nelson, B.C. Geological Survey Branch, and Andre Panteleyev, XDM Consultants Ltd.

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INTRODUCTION

The Nizi property is located 80 kilometres northeast of Dease Lake, British Columbia and 60 kilometres southeast of Cassiar (Figure 1). The Nizi hosts gold-bearing epithermal-type veins associated with felsic volcanic rocks (Cavey and Chapman, 1992; Paul Wodjak, personal communication 1995). The Nizi lies within a poorly understood, highly metamorphosed geologic unit, the Rapid River tectonite (Gabrielse, 1994), which, like the Yukon Tanana Terrane (Mortensen, 1992), is intruded by early Mississippian plutons (Gabrielse *et al.*, 1993). The presence of felsic volcanic rocks within the Rapid River tectonite suggested a comparison with the volcanogenic massive sulphide systems of Kudz Ze Kayah and Wolverine (Nelson, 1997).

This paper is based on a field examination of the property by Nelson and McMillan in 1996 and on more thorough geological study by Plint in 1997 as part of a major exporation program conducted by Madrona Mining Limited. Panteleyev's overview of the epithermal system is based field observations and interactions with Plint during a brief visit to the property in 1997. The overall result of our work is to show that the Nizi mineralization, along with the volcanic rocks that host it, post-date the early Mississippian metamorphic and mid-Permian plutonic bodies that enclose them. The system may be as young as Eocene. It presents a type of mineralization, comparable to Mt. Skukum and the epithermal systems associated with the Carmacks Group in the Yukon, that was not previously known in this area. Consideration of this model may shed light on the source of some multi-element geochemical anomalies defined in the recent Cry Lake RGS release (Jackaman, 1996).

PROPERTY HISTORY

J. Atenbury first staked claims on the Nizi property in 1969. The claims covered a gossanous zone of polymetallic mineralization hosted by quartz veins in "shear" zones. In 1970, a soil-geochemistry survey (84 samples) and reconnaissance geological mapping was conducted. Anomalous concentrations of lead and zinc were discovered associated with a gossanous area immediately northwest of Zinc Lake and with north-trending topographic lineaments near the northwest end of the property (Zimmerman, 1970). The property was optioned to Sumac Mines Limited in 1972 who explored for a porphyry-style copper deposit by systematic geological mapping and soil/silt geochemical surveys. Although several silver-zinc anomalies and a gold anomaly were identified (Rodgers, 1972), the claims were allowed to lapse in 1973.

Regional Resources Limited re-staked the area in 1979. Detailed geological mapping (1:5 000 scale) and geochemical surveys were carried out to assess the precious metal potential. Several gold and silver-bearing veins were outlined during this program (Rowe, 1980). In 1982, Regional Resources conducted a prospecting and rock sampling program in geochemically anomalous areas and reported that the highest gold values were obtained from massive galena-sphalerite-pyrite vein material.

The claims were allowed to lapse. The property was re-staked in 1987 by Izumi Exploration Limited (later renamed Gold Giant Minerals Incorporated). A 36.4 kilometre grid was established. Geological prospecting, geochemical and geophysical surveys were undertaken to re-define known anomalies and veins and to locate new ones. Six main zones of mineralization were identified and named Zones A through F. Precious and base metal mineralization in quartz and quartz-carbonate-sulphide veins associated with north to northwest-trending faults was reported. Additional exploration in 1991 outlined quartz vein stockworks termed the "G Zone" and later the "Discovery Vein" (Figure 2a). Assay values up to 41.0 g/t Au and 764.6 g/t Ag over 1.5 metres were obtained for this area (Cavey and Chapman, 1992; McIntosh and Scott, 1991). A VLF-EM conductor was interpreted to reflect pyritization associated with the quartz stockworks (Cavey and Chapman, 1992).

An airborne geophysical survey was completed in the spring of 1992 (Woolham, 1992) followed by soil sampling, geological mapping and diamond drilling during the 1992 field season. Base and precious metal mineralization associated with minor faults and fractures was reported. The highest assay values were obtained from an area of quartz veining in silicified rhyolite in the

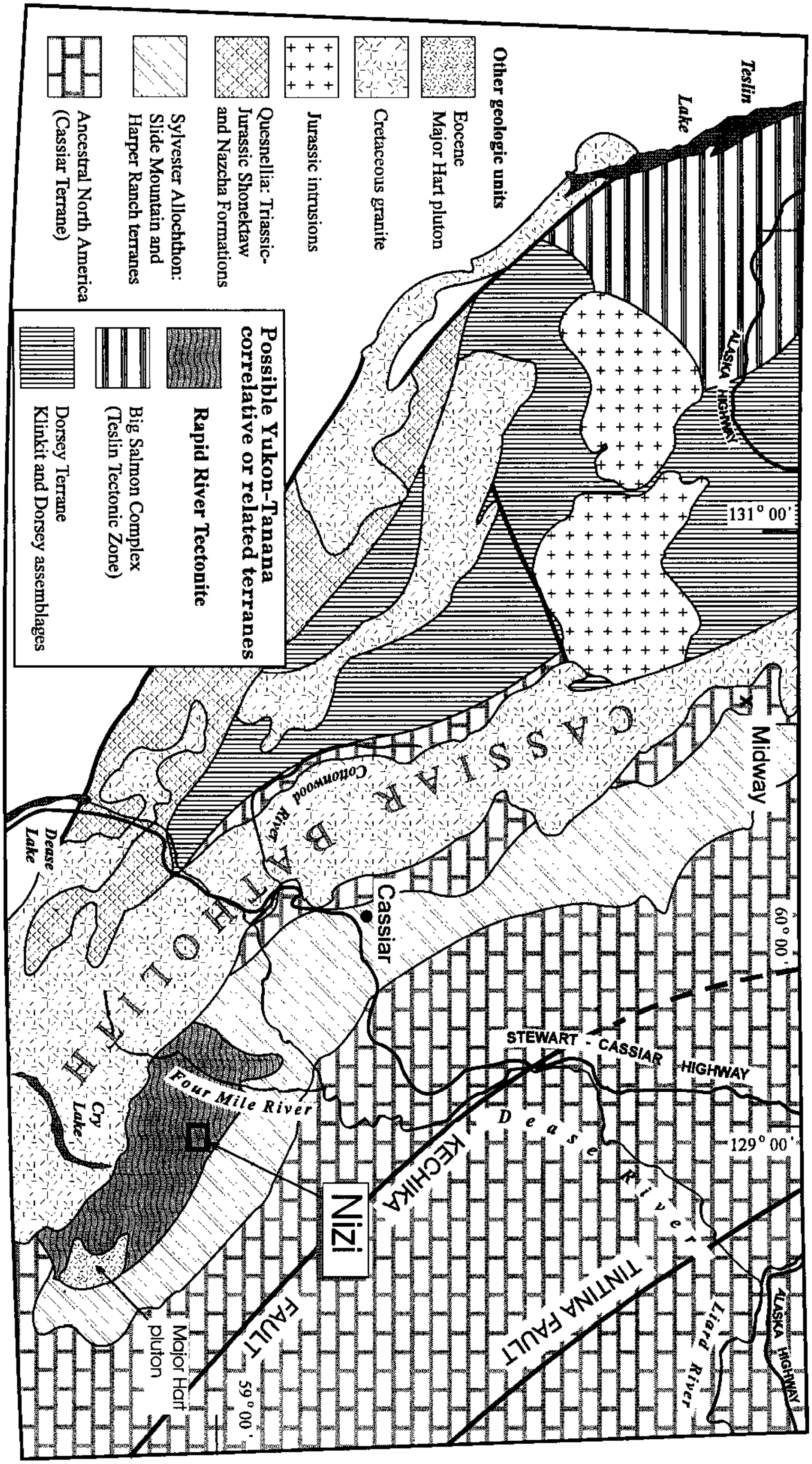

Figure 1. Geological location map of the Nizi property

Discovery Vein area and the nearby, newly identified Surprise Vein (Figure 2). The most significant surface soil gold anomaly coincided with the Discovery Vein. Five drill holes, with a total length of 957.38 metres were drilled. Two holes (NZ92-1, 2) tested the Discovery Vein/Surprise Vein area. The remaining three holes (NZ92-3, 4,5) tested the H Zone, Grizzly Ridge Vein and Gully A Zone, respectively. Three additional holes were drilled in the Discovery Vein area by Gold Giant Minerals Incorporated. Drilling indicated the continuity of gold-bearing structures. Significant gold assays were reported from intervals of smoky blue/grey quartz veins, from grey to black, quartz-flooded rhyolite cut by quartz-carbonate-sulphide veins, and from adjacent fault zones. Since gold assays from drill core were generally lower than surface values (Bond, 1993), the claims were allowed to lapse.

In 1994, claims were re-staked in the Nizi area by Lawrence Barry of Hunter Explorations. The property was optioned by Oro Grande Resources Inc. in 1995. Madrona Mining Limited entered into an agreement with Oro Grande Resources in July 1996. In September 1996, six diamond drill holes with a total length of 921.1 metres were drilled by Madrona Mining in joint venture with Oro Grande Resources. Five holes were drilled in the vicinity of the Discovery and Surprise Veins. One hole was drilled to test the southeastern extension of the Zinc Lake Zone (Zone E of Augsten, 1987 and Bond, 1993). Significant gold mineralization was encountered in holes NZ96-9, 10 and 12. Base-metal mineralization (sphalerite and galena) was encountered in holes NZ96-10, 12 and 13 in a steeply-dipping, northwest-striking zone of fault breccia. The breccia is characterized by the presence of sphalerite-galena-rich and carbon clasts.

In 1997, Madrona Mining undertook further exploration on the property. Plint remapped and relogged preexisting core prior to a 3000-foot drill program that was completed in September.

REGIONAL GEOLOGY

The Nizi property lies within the Sylvester Allochthon, a set of thrust-bounded terranes that lies on top of the Cassiar Terrane (Figure 1). The structurally lowest terrane, the Slide Mountain (Mississippian to Permian ocean basin or marginal basin), is overlain on a major thrust fault by Harper Ranch Terrane (Mississippian to Permian island arc) (Nelson, 1991). Highest in the stack is the Rapid River Tectonite (Gabrielse, 1994; Harms, 1990, 1993), which occupies the southeastern portion of the Sylvester Allochthon and surrounds the Nizi claims (Figure 1). It is an assemblage of amphibolite grade, intercalated mylonitic tectonites and intrusive rocks. Rock types include amphibolite, serpentinized ultramafic rock, marble, garnet-muscovite-zoisite and garnet-biotite-staurolite schists, and quartzite, intruded by plutons of quartz diorite, monzodiorite, diorite and gabbro. Metamorphism and mylonitization predate Late Devonian to Early Mississippian synkinematic quartz diorite (362 to 350 Ma); mid-Permian plutons are also present (Gabrielse *et al.*, 1993). The Rapid River tectonite may have correlatives in the allochthonous terranes west of the Cassiar Batholith (Nelson, this volume).

PROPERTY GEOLOGY

The geology of the Nizi property (Figure 2a) is divided into four major map units. In order of oldest to youngest they are:

1. the Rapid River tectonite: a pre-Mississippian metamorphic sequence of metasedimentary and metavolcanic schist and gneiss, orthogneiss, and ultramafites,

2. an Early Permian(?) intrusive unit of fine- to coarse-grained, non-foliated granodiorite, quartz diorite and diorite,

3. a sequence of felsic to mafic volcanic flows and pyroclastic rocks (hereafter the "Nizi volcanic sequence"), and

4. kaolinitized megacrystic orthoclase-quartz-(biotite) porphyry dikes.

Diorite dikes of unit 2 intrude the metamorphic sequence, and dikes resembling the Nizi volcanic sequence intrude the diorite. The volcanic sequence is thus considered younger than the diorite. Geophysical data and field observations indicate that subsequent faulting (*see* below) has modified the diorite-volcanic contacts. The timing of intrusion of the kaolinitized K-feldspar-quartz porphyry relative to the Nizi volcanic sequence is unknown. However, it apparently occupies much of the fault zone between the volcanic sequence and quartz diorite to the northeast. As the porphyry is not tectonized, it is likely a late intrusion into the fault zone and therefore younger than all other map units.

Unit 1: Metamorphic Sequence (Rapid River Tectonite)

The metamorphic sequence includes quartzite, quartz-feldspar-hornblende-biotite tectonite and orthogneiss, amphibolite, metacarbonate and calc-silicate rock, massive to fish-scale-textured serpentinite and minor muscovite-biotite schist. Compositional layering in the metamorphic sequence varies in scale from one millimetre to several metres. Foliation is moderately to well-developed and defined by hornblende, micas, and/or compositional variation between quartz-feldspar-rich and hornblende-rich lamellae and layers. Locally, the foliation is accentuated by white to grey quartz lenses up to 2 centimetre thick and quartz veins up to 10

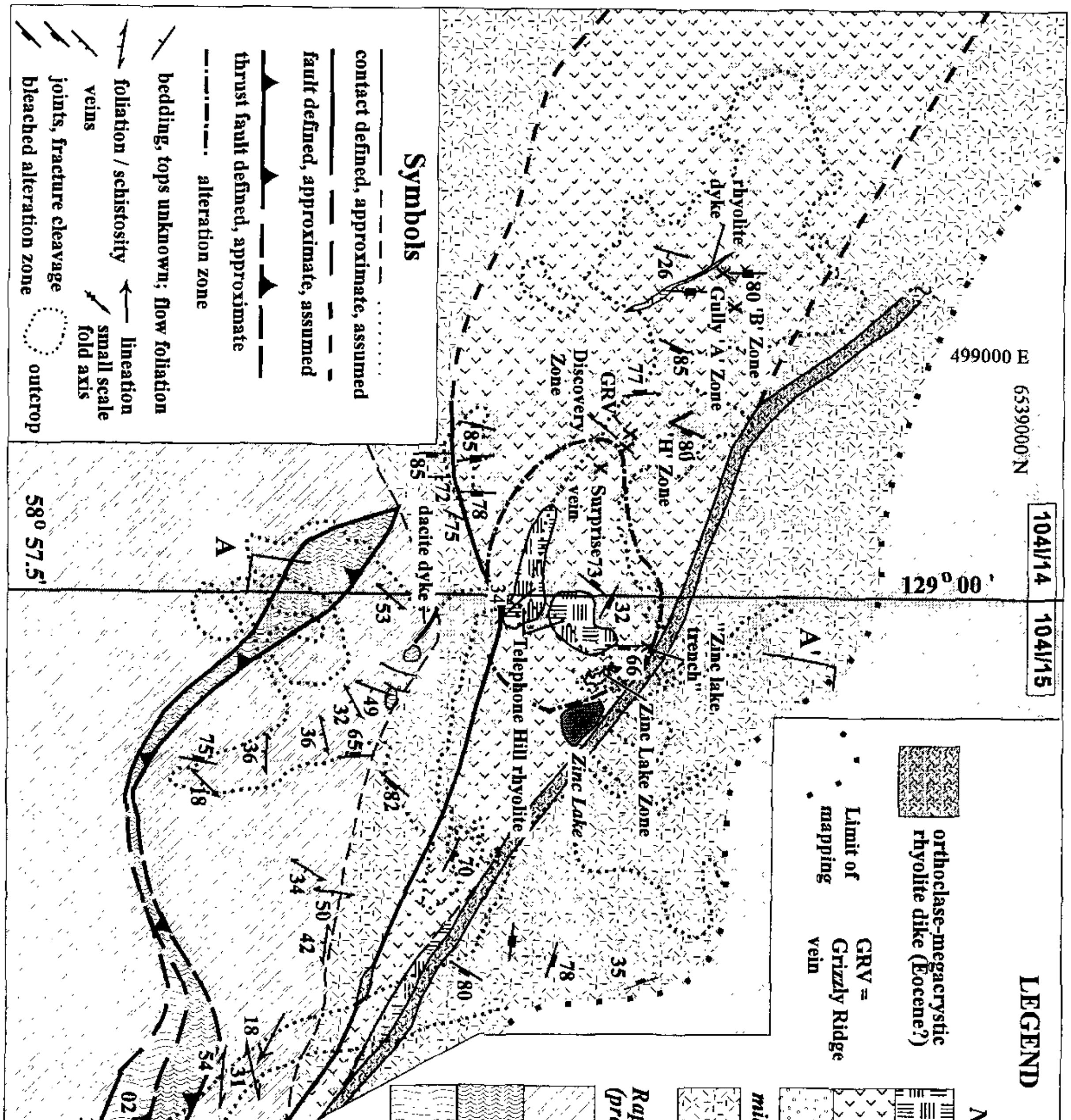

Figure 2a. Geology of the Nizi Claims area. Cross section on Figure 2b.

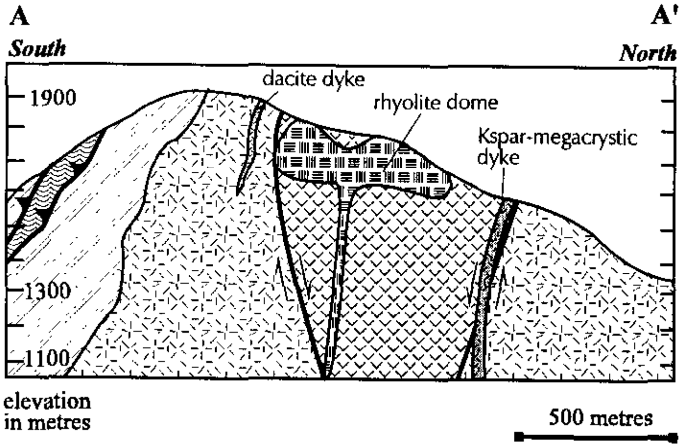

Figure 2b. Cross section A-A' across the "Telephone Hill" area. Legend as for Figure 2a.

centimetres thick. The latter also cut the foliation. In some areas, granitic layers or diffuse lensoidal patches in quartz-feldspar-hornblende tectonite, oriented broadly parallel to the foliation, give the rock a migmatitic appearance. The metamorphic sequence is intruded by metre-scale dikes of granodiorite to diorite of Unit 2 and by dikes of fine-grained, feldspar-quartz porphyry dacite that are probably related to the Nizi volcanic sequence.

The contact between serpentinite and other metamorphic rocks in the sequence is assumed to be faulted due to the extreme compositional difference of their protoliths, the lens-shaped map pattern of the serpentinite and the presence of numerous slickensided surfaces in serpentinite.

The strike of foliation in the Rapid River tectonite varies from northwest to west to, less commonly, northeast; dips are predominantly to the south and southwest. Rootless centimetre-scale folds with axial surfaces parallel to the foliation were observed in boulders of quartz-feldspar-amphibolite orthogneiss, and at one location, a closed fold with a moderately southeasterly plunging axis and a steeply southwest dipping axial plane is exposed in quartz-feldspar-amphibole tectonite. These observations indicate that the foliation in the metamorphic sequence is at least a second generation feature.

Unit 2: Diorite, Quartz Diorite, Granodiorite

Diorite is exposed to the northeast and southwest of the Nizi volcanic sequence (Figures 2a, 2b). To the southwest, the diorite is massive, fine- to coarse-grained with pyroxene and minor amphibole or biotite. Trace amounts of disseminated pyrite are common. To the northeast, the unit consists of white to beige weathering, medium- to coarse-grained quartz diorite to granodiorite with randomly oriented, acicular amphibole crystals. Biotite, commonly chloritized, is present locally. Grain size and compositional variations at the outcrop scale are common in the diorite unit. Inclusions of fine-grained diorite in coarse-grained diorite and quartz diorite, very coarse-grained patches in otherwise medium-grained diorite, and small dikes of granodiorite cutting diorite are common. A fine-grained quartz diorite phase is present along the contact with the Nizi volcanic sequence in outcrop south of Zinc Lake and in creek exposures in the northwestern part of the map area.

In outcrop immediately northeast of Zinc Lake and along the north-northwesterly trending ridge north of Zinc Lake, the quartz diorite is cut by fine grained to aphanitic, feldspar-phyric mafic dikes and by rusty to dirty green weathering, pale green to pale green-grey, feldspar-quartz porphyry dykes. Phenocrysts in the mafic dikes and porphyry are subhedral and generally less than 5 millimetres long. The mafic dikes locally enclose angular clasts of the quartz diorite. In outcrop immediately northeast of Zinc Lake, a mafic dike grades into the feldspar-quartz porphyry suggesting that both rock types are part of the same intrusive event. These dikes are interpreted to be part of the Nizi volcanic sequence. On the mountain southwest of Zinc Lake, dacitic and rhyolitic dikes related to the Nizi volcanic sequence intrude diorite.

Dikes of Unit 2 intrude the Rapid River tectonite and thus are younger than the Late Devonian to Early Mississippian deformation in the tectonite. Permian diorite is common in the Rapid River Tectonite. Bodies of mid-Permian foliated hornblende diorite (266$\pm$ 1.5 Ma) and massive diorite to granodiorite (262$\pm$ 0.5 to 270$\pm$ 4 Ma) are exposed to the northwest and west of the Nizi property (Gabrielse and Harms, 1989). Therefore, Unit 2 is interpreted to be mid-Permian.

Unit 3: Nizi Volcanic Sequence

The Nizi volcanic sequence crops out in a west-northwest trending, wedge-shaped belt that widens to the northwest and pinches out to the southeast (Figure 2a). The sequence is composed of approximately 80% intermediate to mafic feldspar phyric and amygdaloidal volcanic flows, 10% intermediate lapilli-crystal tuffs and 10% rhyolite flows and dikes. These rocks, in contrast to the Rapid River tectonite, are unmetamorphosed and unfoliated; although in part they are affected by very intense, texture-obliterating silicification.

Rhyolitic volcanic flows and minor tuffs are exposed in an irregular map pattern along the easterly-trending ridge immediately northwest of Zinc Lake (Figure 2a). This occurrence is referred to informally in this report as the Telephone Hill rhyolite. A second discrete rhyolite body hosts mineralization in the Zinc Lake Zone. Northwest, north and northeast-trending, subvertical rhyolitic dikes cut the volcanic sequence. They are commonly less than 5 metres, but locally up to 30 metres, wide. Rhyolite weathers rusty yellow to white or pale pinkish orange. It is pale grey, pale green or white on the fresh surface and typically aphanitic with conchoidal, angular or blocky fracture patterns. Disseminated pyrite, generally less than 3%, is common. Rhyolite flows typically contain blocky and minor lathshaped feldspar phenocrysts or glomerophenocrysts, heavily altered to microcrystalline quartz, and subhedral quartz phenocrysts. Phenocrysts are typically less than 0.5 millimetres in the largest dimension and comprise approximately 15% of the rock. They define a flow foliation in the Telephone Hill rhyolite. The strike of the flow layering is highly variable, but dip angles are consistent at about 40 to 50 degrees.

Intermediate, polylithic, lapilli-crystal tuff and very minor ash tuff underlies the Telephone Hill rhyolite. Lapilli are typically less than 5 millimetres long but locally range up to 2 centimetres and consitute about 15% of the rock. At one locality, a crystal-lithic lapilli tuff contains large tabular, subrounded feldspar crystals up to 1.5 centimetres diameter, angular microcrystalline quartz fragments, rounded fine-grained, dark green volcanic fragments, rhyolite fragments with flow foliation and rare, rounded igneous fragments composed of medium-grained quartz, feldspar and biotite. Angular, cuspate fragments altered to dark green chloritic material in tuff are interpreted to be glass shards on the basis of their shape.

The intermediate (? dacitic) volcanic flows weather rusty orange to a brownish olive green. They range from green-grey to pale green on the fresh surface. Feldspar phenocrysts are interpreted to be plagioclase and K-feldspar based on their lath-like and blocky outlines, respectively, and on polysynthetic twinning in plagioclase. Feldspar phenocrysts, generally <1.0 millimetre in their longest dimension, are replaced by milky white or grey microcrystalline quartz and/or altered to dark green chloritic material. In thin section, sericitic alteration of feldspars and microcrystalline quartz pseudomorphs after feldspar are observed. Rare anhedral clots of quartz observed in thin section may be amygdules or partly resorbed and pseudomorphed feldspar phenocrysts.

Intermediate (andesitic?), amygdaloidal, plagioclase hornblende, and locally augite-phyric volcanic flows are most common in the northwest corner of the map area, where they apparently grade vertically and laterally into intermediate (dacitic?) flows and tuffs. Intermediate flows are also exposed along the base of the ridge northwest of the Discovery Vein area. The flows weather a dark grey to maroon color and are grey-maroon to green-grey on the fresh surface. Although generally aphanitic, they locally contain plagioclase phenocrysts (<5%) less than 0.5 millimetres in diameter, and amygdules filled with dark green chlorite and milky white, microcrystalline quartz. The plagioclase phenocrysts define a flow foliation that strikes northeast and dips gently to moderately southeast. They are typically altered to a mixture of carbonate, sericite, pyrite and chlorite.

A general volcanic stratigraphy for the Discovery Vein area is evident in drill core. The stratigraphic sequence (from the base) consists of:

(a) mafic (andesitic), green, amygdaloidal, plagioclase-phyric flows and minor intercalated lithic lapilli tuffs ,

(b) intermediate (dacitic), grey-green to grey, lithic-crystal lapilli tuffs,

(c) intermediate to mafic, grey to green-grey (dacitic to andesitic) amygdaloidal-feldspar-phyric flow, which is commonly hematized and limonitized.

Contacts range from sharp and irregular to gradational over 5 to 10 centimetres. Flow foliation is uncommon in flows of units (a) and (c). Measurement of the angle between flow foliation and the core axis, together with flow foliation attitudes observed in outcrop, indicate that the volcanic stratigraphy is moderately dipping (average about 40^{0}). Not all units are present in each drill hole. Lithic lapilli tuff is encountered only in holes NZ96-11, 12 and 13. In addition to the volcanic units, a near-vertical grey, feldspar-phyric rhyolite dyke is present in all but drill hole NZ96-11, between units (b) and (c).

The Nizi volcanic sequence is younger than the quartz diorite that it intrudes, although no absolute age determinations exist for the sequence. No zircons were recovered from a sample of Zinc Lake Zone rhyolite collected in 1996.

Unit 4: Kaolinitized Quartz-K-Feldspar Porphyry

A buff to locally maroon weathering quartz-K-feldspar porphyry is exposed in isolated outcrops along the northeastern contact of the Nizi volcanic sequence with the quartz diorite. K-feldspar phenocrysts are subhedral and range from 5 millimetres to 2 centimetres in diameter, averaging 1 centimetre. The K-feldspar phenocrysts are entirely altered to kaolinite in most exposures and commonly only subhedral pits remain on the weathered surface. Quartz phenocrysts are clear, vitreous, subhedral to anhedral and from 1 to 5 millimetres in diameter. Minor biotite phenocrysts are observed locally. The matrix is pale pink to buff weathering, slightly greenish beige on the fresh surface and aphanitic.

The contacts of the kaolinitized porphyry are not exposed, however its extrapolated map pattern on Figure 2a shows that it is a dike. Along most of its length it separates the Nizi volcanic sequence to the west from the acicular amphibole quartz diorite to the east. However, at its northern end it is enclosed within the quartz diorite, and probably intrudes it. The absence of a tectonic fabric in the porphyry and its coincidence with the regional strike-slip fault identified from apparent resistivity contours (*see* below), suggest that it intruded along the fault after motion ceased. It is thus younger than the Nizi volcanic sequence. However, if faulting was largely synchronous with the extrusion of the Nizi volcanic sequence, the porphyry may be a late subvolcanic intrusion related to the Nizi volcanic sequence. Considering that rhyolite dikes intrude the Nizi volcanic sequence, the latter interpretation is plausible. Gabrielse (1994) mapped the kaolinitized feldspar-quartz porphyry as belonging to the same intrusive suite as the Early Eocene Major Hart pluton, which is exposed about 20 kilometres to the southeast of the Nizi property (Figure 1).

Depositional setting of the Nizi volcanic sequence

The Nizi volcanic sequence consists of amygdaloidal and porphyritic flows and lapilli, lithic and crystal tuffs. No pillowed flows, pillow breccias or intercalated clastic sedimentary rocks are present. These observations suggest that the Nizi volcanic sequence was erupted subaerially. The map pattern of the rhyolite exposed at Telephone Hill and the wide variation in flow foliation attitude supports the interpretation that the rhyolite is a flow dome (Figure 2b). The presence of lithic and ash tuff, locally showing planar layers ("beds") underlying the rhyolite probably represent explosive pyroclastic activity that predated extrusion of the rhyolite. The Zinc Lake Zone rhyolite lacks flow foliation and is spatially associated with the Telephone Hill rhyolite. It may be a small feeder dike related to the Telephone Hill rhyolite.

Structural geology

The Nizi volcanic suite lies within a southeasterly-tapering graben bounded on both sides by steeply-dipping faults with normal sense of stratigraphic separation, as indicated by the outcrop patterns on Figure 2a and illustrated in the cross section in Figure 2b. Wherever contacts between the Nizi volcanics and adjacent plutonic bodies are seen, they are faulted, with zones of shearing, chloritic fractures, and slickensides. Analysis of apparent resistivity contour maps indicates that northwest-trending fault zones and sets of northeast-trending and north-trending fractures or faults dissect the Nizi property (McGowan, 1997). Comparison of the resistivity contours with field data suggests that the northeastern contact of the Nizi volcanic sequence with the quartz diorite is a regional, dextral strike-slip fault. The fault dextrally offsets three, northeast-trending, negative resistivity anomalies by 300 to 400 metres.

Jointing in and near the Nizi volcanics probably formed in response to several processes, such as igneous cooling in magmatic and volcanic rocks, hydrothermal fracturing and subsequent tectonism. Compilation of joint orientations from Bond (1993) and data collected during the 1997 field season shows a wide variety of strike orientations of both joints and fracture cleavage, with moderate to vertical dips predominating. In the mineralized areas north, northwest and northeast-striking, steeply dipping to vertical joints and fracture cleavage are well developed.

Centimetre-scale, strike-slip offset of mineralized quartz veins indicates that at least some of the joints and fracture cleavage are related to faulting. Commonly, motion along the northwest-striking faults is dextral whereas along northeast-striking faults it is sinistral. This is best illustrated in the Discovery Vein area. There, a northwest-striking, vertical, dextral strike-slip fault offsets a contact between an intermediate flow to tuff and a rhyolite dike by 27.5 metres. The fault also offsets and has brecciated the Discovery Vein. Smaller scale, northeast-striking, subvertical to vertical, sinistral faults offset the Discovery Vein on the order of 50 centimetres or less. All the faults are marked by fracture cleavage. The dextral and sinistral strike-slip faults are interpreted to be largely coeval as no offset of either fault is observed where they intersect.

Bond (1993) reported northwest-trending, dextral strike-slip faults and northeast-striking, sinistral strike-slip faults in the H Zone area. A brief examination of the H Zone by Plint confirmed that it is a north-northeast-trending, recessive weathering, fault zone of uncertain displacement, offset dextrally by northwest-trending faults.

Most of the northeast-trending faults/fractures occur to the southwest of the regional, northwest-striking, dextral strike-slip fault that bounds the Nizi volcanic sequence to the northeast (McGowan, 1997). This observation suggests that the northeast system is either older than, or controlled by the regional northwest-striking fault zone. This interpretation is consistent with laboratory analyses of strike-slip systems. Models show that deformation is taken up along synthetic and antithetic shears ("Riedel" shears) *prior* to motion along the principal fault zone, although motion on the Riedel shears may continue after motion along the principal fault (e.g. Sylvester, 1988). Antithetic shears develop at angles of 60 to 75 degrees to the principal fault zone and synthetic shears at an angle of 15 to 20 degrees to the principal fault zone. Therefore, the northeast-striking faults are probably antithetic shears (R shears) to the more through-going, northwesterly-striking dextral strike-slip fault.

Fault motion along zones of north-trending, subvertical to vertical fracture cleavage and joints has not been unequivocally documented in the field. At one outcrop in the Gully A Zone, brecciation and steeply plunging slickensides are developed in a 3 metre wide zone of vertical, north-striking fractures. This observation suggests that some fault motion has occurred. In a northwest-striking, dextral strike-slip fault system, north-trending normal (extensional) faults are expected to develop. Therefore, it is probable that any fault motion along the north-trending fracture/fault system is normal. The northerly-striking H Zone may also be a normal fault.

We conclude that the Nizi volcanic sequence records deformation related to regional strike-slip faulting. The northwest, north and northeast-trending fracture cleavage and joints that dominate in mineralized areas are interpreted to reflect this faulting, although documentation of displacement is hindered by the lack of marker beds.

Mineralization and alteration

Mineralization on the Nizi property is a vein-stockwork system with associated hydrothermal brecciation. Two distinct styles are present: sulphide-poor, gold-silver-quartz veins and stockworks associated with pervasive silicification, and sulphide-rich iron carbonate-sphalerite-galena veins associated with pervasive carbonate alteration.

There are six main mineralized areas outlined to date on the Nizi property: Zinc Lake Zone, Discovery Vein/Surprise Vein, Grizzly Ridge Vein, H Zone, Gully A Zone and B Zone. In addition, the Hill Zone is introduced here as an area of interest on the basis of 1997 mapping and assays reported by Gold Giant (Bond, 1993).

Gold-Silver-Quartz Mineralization

Discovery Vein/Surprise Vein area

The Discovery /Surprise Vein area is characterised by multistage, microcrystalline quartz-carbon-sulphide barite stockworks. The Discovery Vein is the largest surface expression of the mineralization, although small areas to the southeast (Surprise Vein) and to the northwest ("DV2" of Bond, 1993) are also exposed. The Discovery Vein is actually a stockwork zone which is most evident only at the northwestern and southeastern ends of the "vein". The stockworks trend west-northwest and are steep to vertical. The zone pinches and swells along strike and reaches a maximum true width of 2.5 metres. It cuts across a contact between a rhyolite dike and an intermediate volcanic tuff or flow. Very fine-grained pyrite, galena, sphalerite, chalcopyrite, tetrahedrite and acanthite are disseminated or follow microfractures in the quartz stockworks. Pyrite also occurs in fine veinlets up to 5 millimetres wide.

In 1997 drill core, sulphide-carbonate veins are seen to crosscut the gold-quartz veins (holes NZ-97-16 at 17-18 metres and NZ-97-18 at 115-118 metres). This relationship shows that gold-enriched quartz veining preceded the sulphide-carbonate style of mineralization.

Channel samples of the Discovery vein have returned the following selected high-grade values: 27.09 g/t Au and 1220.6 g/t Ag over 2.0 metres; 15.09 g/t Au, 1073.2 g/t Ag over 3.5 m; 8.91 g/t Au, 596.6 g/t Ag over 1.0 metres, 1.54 g/t Au, 190.3 g/t Ag over 1.0 metres. Channel samples from the Surprise Vein area ran 6.5 g/t Au over 1.3 m, 462.9 g/t Ag over 0.8 m and 2.16 g/t Au, 496.8 g/t Ag over 1.0 metre (Bond, 1993). The Discovery Vein area represents the best exploration target identified to date on the Nizi Property. Of the fourteen drill holes have been completed in the area, assays in all but two have confirmed the presence of significant gold-silver mineralization in microcrystalline quartz-carbon-pyrite-barite veins and stockworks, although the values are erratic and on the whole somewhat lower than the best surface results, with notable exceptions such as 3.54 g/t Au, 49.1 g/t Ag over 6.1 metres in DDH NZ-96-9 and 1.44 g/t Au, 27.21 g/t Ag over 6.88 metres in DDH NZ-96-10 (Day, 1996).

Zinc Lake Zone

The Zinc Lake Zone is hosted by white to pale grey to green, quartz phyric, silicified rhyolite, cut by north and northwest-striking, steep to vertical joints. Zones of fracture cleavage, generally less than 1 metre wide are developed parallel to the north-striking joint set. The rhyolite is silicified and locally pyritized with 1 – 10% disseminated pyrite along the fracture cleavage zones. Minor iron carbonate veins occur along some zones of fracture cleavage. Steep to vertical lenses of white to grey microcrystalline quartz, carbon and pyrite trend parallel to the joints. The lenses, typically less that 20 centimetres wide, pinch out along strike and are confined to an area of intense iron-staining in the rhyolite.

The largest quartz lens is approximately 3 metres wide by 10 metres long in outcrop. It is composed of microcrystalline quartz cut by randomly oriented, carbon-filled, hairline fractures that are in turn cut by a network of irregular pyrite veinlets. Two grab samples from the main quartz lens, collected by Madrona Mining Limited, returned values up to 3.14 g/t Au and 950.0 g/t Ag. Microcrystalline quartz-barite stockworks enclose angular centimetre-scale clasts of bleached rhyolite. They broadly follow northeast-striking, vertical fractures. Grab samples returned values of 0.39 g/t Au and 1.3 g/t Au. One hole (NZ96-14) has been drilled in the area of Zinc Lake Zone. It intersected a sequence of intermediate, heterolithic lapilli tuffs and minor silicified amygdaloidal to massive flows. The failure of this hole to intersect rhyolite may reflect the steeply inclined contacts of a subvolcanic intrusion.

Grizzly Ridge Vein

The Grizzly Ridge vein was examined briefly by Plint and Panteleyev. It is a northerly-trending quartz vein exposed in two small outcrops and in felsenmeer over a distance of 125 metres, located on the ridge top 100 metres south of the Discovery vein. The Grizzly Ridge vein consists of white, massive, fine-grained quartz cut by minor carbon-filled hairline fractures. In talus surrounding the vein, the rock is strongly altered to a pale yellow/chalky white material cut by fine, microcrystalline quartz veinlets, up to 3 metres from the vein. This alteration was previously reported to be "sericitic" although no sericite was observed in hand sample. Similar alteration envelopes less than a metre wide are present along nearby northeast-striking, subvertical, fracture cleavage zones. Unlike other gold-bearing veins on the property, it formed as a single stage vein containing little carbon or sulphides and no barite. A 2.5 m chip sample assayed 0.270 g/t Au; all other samples ran less than 0.1 g/t (Bond 1993).

Hill Zone

Bond (1993) reported quartz veins that crop out 150 m south of the Gully A Zone. Mapping in 1997 identified northerly-trending quartz-barite-pyrite stockworks cut by carbon-filled hairline fractures in a strongly silicified host rock and an east-striking, 40 centimetres wide, quartz-barite-pyrite-chalcopyrite vein in a mafic, plagioclase-phyric flow. Grab samples of quartz vein returned low values of 3.58 g/t, 0.86 g/t , and 204 ppb Au (Madrona Mining Ltd., unpublished data).

Iron Carbonate-Sphalerite-Galena Mineralization

H Zone

Sheer cliffs make much of the H zone inaccessible. It is interpreted to be a northerly-trending fault zone marked by well developed planar, subvertical joints that strike north-northwest to north-northeast. A banded carbonate-quartz-sphalerite-galena-pyrite vein with an exposed true width of 2 metres occupies part of the fault zone. The vein orientation is parallel to planar joints in the host rock. Within 50 centimetres of the vein the host rock is altered to a pinkish beige, granular material cut by randomly oriented limonitic fractures. In general, gold values are low although a 1.8 metre chip sample of sphalerite-galena- pyrite-carbonate-rhyolite breccia returned values of 2.26 g/t Au, 278.1 g/t Ag, 1900 ppm Pb and 32.1% Zn (Bond, 1993).

Gully A Zone and B Zone

The main showings of both the Gully A and B zones are iron carbonate-microcrystalline quartz-rhodochrosite-sphalerite-galena-pyrite veins controlled by north-striking subvertical fractures. Both exhibit a pinkish-beige, granular alteration of the host rock identical to that observed in the H Zone. The alteration contains disseminated blebs of pyrite and trace galena and is cut by numerous, randomly oriented limonitic fractures. The mineralized interval at the Gully A showing is a 20 centimetre wide zone of hydrothermal breccia. It consists of angular clasts of sulphide (sphalerite, pyrite and minor galena) and of host rock in an iron carbonate matrix. The host rock to the zone is silicified green-grey, plagioclase-phyric mafic volcanic flow which is altered within 2 metres of the eastern margin of the breccia.The best assays for Gully A Zone were 11.38 g/t Au and 22.4 g/t Ag (Bond 1993).

Zone B consists of a vertical, north-trending, banded carbonate-sphalerite-quartz vein exposed over 0.5 metres. Host rocks to the vein are intermediate to mafic volcanic flows. The host rocks within 1.5 metres of the vein show the same granular alteration as those at the Gully A and H zones. Carbonate alteration that is subparallel to a vertical, east-striking, 2 m wide zone of fracture cleavage cuts the host rock and the alteration. Bond (1993) reports grab sample assays of 1.2 to 3.63 g/t Au and 3308.6 to 5485.8 g/t Ag for B Zone veins.

Alteration

Rocks underlying the Nizi property are weakly to moderately altered over a wide area. Some of the alteration appears to be aligned along the contact of the mid-Permian(?) intrusion that bounds the Nizi volcanic sequence on the northeast (Fig. 2a). Moderate to intense silicification and microscopically visible sericitic alteration is best developed in the area of the Discovery Zone and related showings, and carbonate alteration and veining occurs with varying intensity throughout the area sampled. An area of patchy to pervasive silicification, sericite alteration and destruction of primary igneous textures encloses the main area of rhyolite domes, quartz stockwork mineralization and precious metal mineralization. To the west, mineralization includes more base metals and is related to carbonate veining and alteration. As a generalization, there seems to be a zoning outward from intense silicification near the rhyolites, through sericitic alteration to a fringe of carbonate alteration. This corresponds to the metal zoning pattern from precious metal-enriched quartz veins and stockworks, outward to lower precious metal contents in sulphide-carbonate veins. In the outer part of the zone, chlorite occurs as an alteration product after feldspars, fills amygdules and forms fractures and veinlets with carbonate. Epidote is present locally as veinlets, with or without carbonate. Epidote alteration is particularily strong adjacent to the faulted contacts between the Nizi volcanic sequence and the surrounding plutonic rocks. Conclusive evidence is lacking, but the sericitized and silicified zones may be overprinted on an earlier propylitic assemblage that could be of regional metamorphic origin, or be intrusion-related. The carbonate alteration event or events are more widespread and spanned the development of the other alteration assemblages.

Summary of vein types and distribution

Gold and silver-bearing quartz veins and stockworks consist of microcrystalline to very fine-grained white to grey quartz and carbon, commonly with white subhedral to euhedral barite, finely disseminated veinlet pyrite, and minor iron carbonate. They occur in the Zinc Lake Zone, the Discovery Vein/Surprise Vein, and in the Hill Zone. In these low-sulphide veins (total sulphides less than 5%), disseminations of sphalerite, galena, acanthite, tetrahedrite and rare chalcopyrite are identifiable in polished section and rarely in hand sample. Gold and silver are in electrum, which forms tiny grains intergrown with the sulphides and sulphosalts, or included within them. The gold and silver-bearing quartz veins show minor quartz comb texture, visible with a hand lens or in thin section, and rare vugs, but otherwise exhibit few void-fill textures.

Sphalerite-galena, gold-bearing, iron carbonate-quartz veins are present in the Gully Zone, B Zone and H Zone. These veins, with total sulphides from 20 to 40%, commonly exhibit colloform banding, crustification, cockscomb textures and multistage, hydrothermal breccia textures. On the basis of textures and mineralogy, mineralization on the Nizi Property is best described as low sulphidation (or "adularia-sericite"), sulphide-poor, epithermal mineralization.

The key result of the 1997 exploration program is recognition that significant gold mineralization is consistently associated with discrete zones of microcrystalline quartz-carbon-pyrite-barite-carbonate silicification (e.g. Zinc Lake Zone, Surprise Vein, Discovery Vein, Hill Zone) rather than pervasive quartz flooding. Carbon, previously reported as tourmaline, is present in both the gold-bearing quartz and in the host rocks, commonly spatially associated with pyrite. It occurs as disseminations or along fine, dark grey, hairline fractures that may be planar and parallel to jointing, oriented perpendicular to vein walls, or in random networks. Gold grades appear to be independent of the amount of pyrite and immediate host rock type. However, the areas of strongest gold-quartz mineralization cluster near the Zinc Lake and Telephone Hill rhyolite bodies (Figure 2a). In outcrop, the silicified zones are discontinuous, commonly lensoid and consist predominantly of quartz stockworks with lesser quartz matrix in hydrothermal breccias and silica replacement ("quartz-flooding") of wallrock. The iron carbonate-sulphide-quartz veins and hydrothermal breccias are apparently late-forming features, compared to the silicification and gold-(silver)-quartz mineralization. "Massive sulphide clasts" identified by Day (1996) are part of a multistage, epithermal carbonate-sulphide-quartz breccia and do not reflect a volcanic massive sulphide system at depth.

Physical Controls on Mineralization

Epithermal deposits vary widely in form because of the low pressure, hydrostatic conditions under which they form (Sillitoe, 1993). Rock permeability and rheology control the sites of fluid flow and metal deposition. Rock permeability may be controlled lithologically, hydrothermally and/or structurally (Sillitoe, 1993, 1997). Typical structural controls are steeply-dipping faults, ring fractures in calderas or fractures in rhyolite flow domes. Overpressured hydrothermal fluids result in hydrothermal brecciation, particularly in highly competent rocks. The hydrothermal fluid, if highly acidic, may also dissolve the host rock. Contrasting rock types may focus fluids by providing a system of aquifers and acquitards.

The presence of carbonate-sulphide-quartz veins, pyritization and bleaching alteration along fractures in the Gully A and B zones and "sericite" alteration along NE striking fractures north of the Discovery Vein, indicates that pre-existing structures have influenced hydrothermal fluid flow in the Nizi volcanic sequence. This influence is most apparent in the carbonate-sulphide-rich mineralization. In one core intersection, NZ96-9, carbon-bearing chalcedonic quartz occurs in tension gashes related to a small-scale fault. In several instances, strike-slip faults offset and brecciate the gold-bearing quartz veins and stockworks, so at least some of the faulting postdated the mineralization.

The gold-bearing quartz veins and stockworks are invariably microcrystalline, multistage, and locally brecciate and/or incorporate fragments of the host rock. Texturally, they show little evidence of open space filling. Locally, carbon-filled black hairline fractures are oriented normal to vein walls indicating extensional opening of fractures after growth of the quartz. More commonly, however, carbon-filled fractures are planar with no preferred orientation or form branching irregular networks in veins or quartz flooded zones. The gold-bearing quartz veins and stockworks are not restricted to a specific rock type. In the subsurface, they concentrate in rhyolite, but also occur in lithic-crystal lapilli tuff and in amygdaloidal, feldspar phyric intermediate to mafic (?) flows. The only consistent correlation is between gold-bearing quartz veins and rhyolite dikes, which at least near the Gully A Zone occupy the same structures (Figure 2a). The migration of gold-bearing fluids may have been controlled largely by dilation presumably caused by overpressured, hydrothermal fluids, rather than filling of pre-existing open spaces.

Age of mineralization

Galena was collected from the H Zone in 1996 for lead isotopic analysis. Its lead-lead isotopic signature (Figure 3) plots above, and near the very young end of the shale curve defined by Godwin and Sinclair (1982). It is similar to lead from veins and skarns near the Seagull Batholith, the Cassiar gold-quartz veins, Midway, Butler Mountain and other Cretaceous-Early Tertiary epigenetic deposits in the Cassiar area (Bradford, 1988). The Midway manto system is associated with a cryptic granite; alteration there is about 70 Ma by K/Ar methods. Butler Mountain is associated with 50-Ma quartz porphyry dikes. Both are hosted by carbonate strata of the continental Cassiar Terrane. By contrast, the Early Cretaceous Table Mountain veins and Seagull Batholith deposits occur in isotopically more primitive, allochthonous, non-cratonic host rocks. This difference in host rocks may contribute more to their less evolved lead signatures than do the small difference in ages of epigenetic mineralization.. Similarly, the slightly less radiogenic nature of the Nizi lead than Midway and Butler Mountain may well be due, not to an older age, but to the more primitive nature of the rocks in the Sylvester Allochthon, as opposed to the Cassiar Terrane.

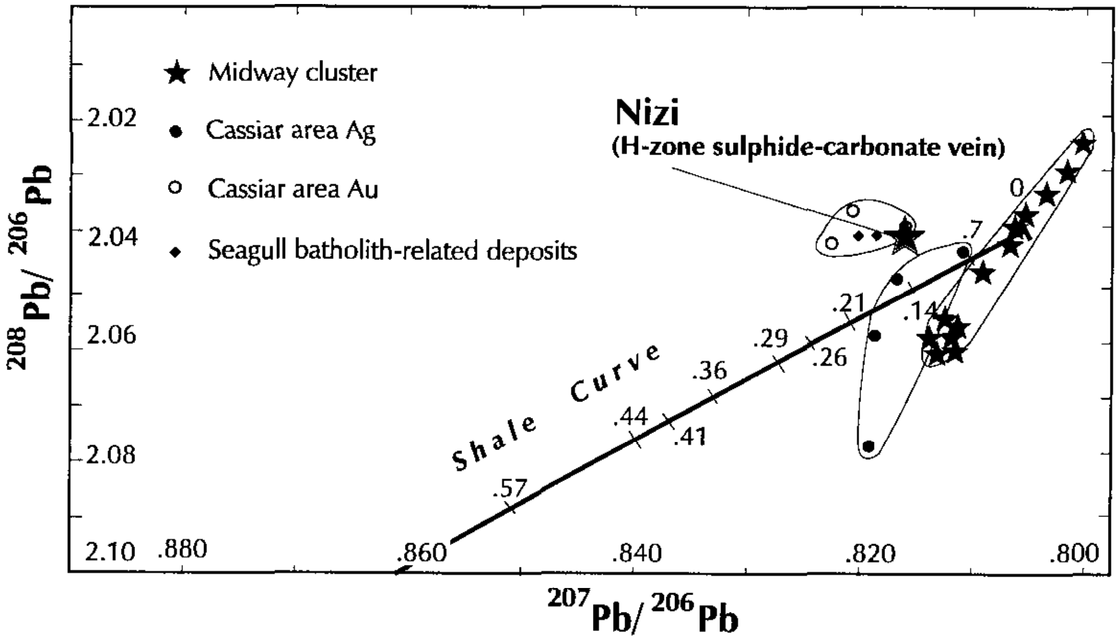

Figure 3. Lead isotopic signature for galena from Nizi sulphide-carbonate vein: comparison with other Cassiar area epigenetic deposits.

CONCLUSIONS

The Nizi vein system has many points of affinity with classic epithermal systems. It is a set of gold-bearing chalcedonic quartz-bladed barite vein-stockworks and sulphide-carbonate vein, developed within an intermediate to felsic volcanic sequence in a structural regime of strike-slip and related faulting. The highest grade vein-stockworks are associated with rhyolite flow domes and a zone of intense silicification and pyritization. They are sinuous, lensoid, multi-stage chalcedonic vein swarms, in places with breccia textures involving wall rock fragments. Sulphide-carbonate veins occur peripheral to the central gold-quartz stockwork zone. Sulphide-carbonate also occurs as a late phase within the Discovery Vein in the central zone, crosscutting the gold-bearing chalcedonic quartz. It probably signifies cooling of the hydrothermal system.

The very young inferred lead isotopic age of the sulphide carbonate veins suggests that the mineralized system is Cretaceous-Tertiary in age. The coincident centering of the alteration halo and the gold-quartz veins around the rhyolites near Zinc Lake strongly favors cogenesis between Nizi volcanic activity and the epithermal event. If this inference is correct, then the Nizi volcanics are, like the veins, Cretaceous-Tertiary in age. The association of this system with northwest-trending dextral strike slip faults is certainly consistent with regional tectonics in Cretaceous-Tertiary time, when northern British Columbia was slivered and dextrally shuffled along such major northwesterly faults as the Kechika, the Cassiar and the Tintina (Figure 1; Gabrielse 1985).

The nearest known body of this age is the Major Hart pluton (Figure 1), described by Gabrielse (1994) as partly miarolitic granite. Gabrielse assigned the kaolinized quartz-Kspar porphyry on the Nizi property to the Eocene suite, although in large-scale mapping he did not have the opportunity to trace out its remarkable strike length: on sheet 104I/15 it appears as a small blob. The spatial association of the porphyry dike with the Nizi volcanic suite suggests that it was a late phase of the sequence. We therefore tentatively assign the entire Nizi volcanic sequence to the Eocene. By this we also infer an igneous-epithermal system that potentially extends from the Major Hart pluton as far north as the Four Mile River.

This suite correlates with other post-orogenic, mid-Cretaceous to Eocene, mafic to felsic volcanic suites in the northern Cordillera. The post-orogenic volcanism clusters into three age groups: mid-Cretaceous (e.g. Mt. Nansen Group, 105 Ma), Late Cretaceous (e.g. Carmacks Group, 70 Ma) and Eocene (e.g. Sloko Group, Skukum Group and unnamed bimodal volcanic rocks along the Tintina dextral strike-slip fault system). Gold-silver epithermal mineralization is associated with all of these units (e.g. Christie *et al.*, 1992).

A strong multi-element stream geochemical anomaly is associated with the Nizi (Jackaman, 1996). Other multi-element anomalies identified by the Cry Lake regional geochemical survey and not associated with known bedrock showings, particularily those on the northwest trend defined by the Nizi and the Major Hart pluton, may also be attributable to epithermal-type mineralization.

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